OpreX™ Analyzer | Application Notes

Sulfur Dioxide Scrubber: pH & Conductivity Control

pH/ORP and Conductivity Measurement

Introduction

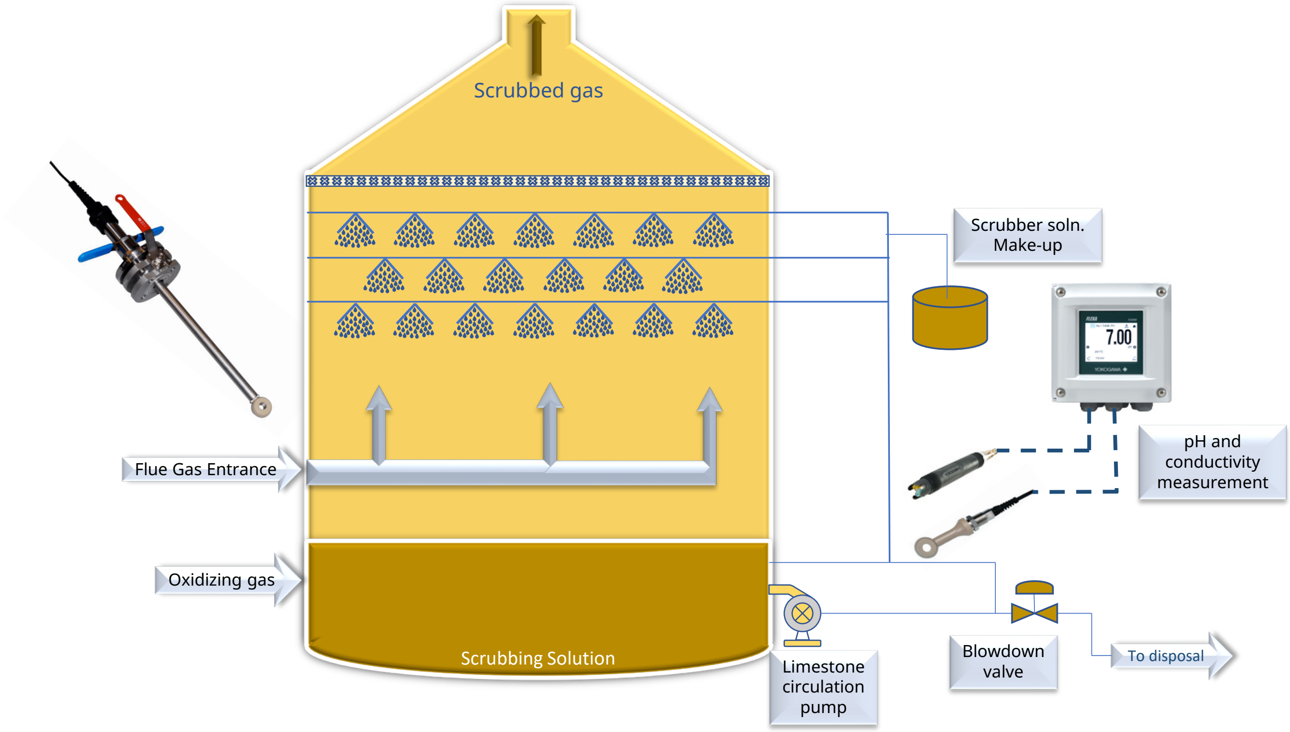
Power plant boiler houses are designed to burn coal or high sulfur oil. Federal and State pollution regulations require power plant boiler houses to "scrub" (remove) sulfur dioxide (SO_2) from flue gases to fulfill emission limits. SO_2 in flue gases is known to be harmful to the environment as it is one contributor to the formation of acid rain. pH control is critical for the proper functioning of the scrubber system. Flue gas desulfurization (FGD) technology, commonly referred to as a scrubber, is a proven and effective method for removing sulfur dioxide emissions from the exhaust of coal-fired power plants.

Scrubber System

The basic principle of a sulfur dioxide scrubber system is the removal of SO_2 by using its chemical characteristics to combine with water. In some cases, parallel rotating rods create a series of short-throat Venturi openings. A series of low pressure, large orifice spray nozzles direct the scrubbing solution into the system. "Scrubbing liquor" is introduced into the system with the flue gas stream. Depending on the scrubber design, the gas can flow either concurrent (with) or counter-current (against) the scrubbing liquor. The high velocity turbulence caused by the Venturi openings ensures maximum gas to liquid contact. Here, the droplets absorb the SO_2 and impact and drop particulates out of the stream. The scrubbed gas is then sent through a demister or re-heater to prevent condensation and exhaust to the atmosphere.

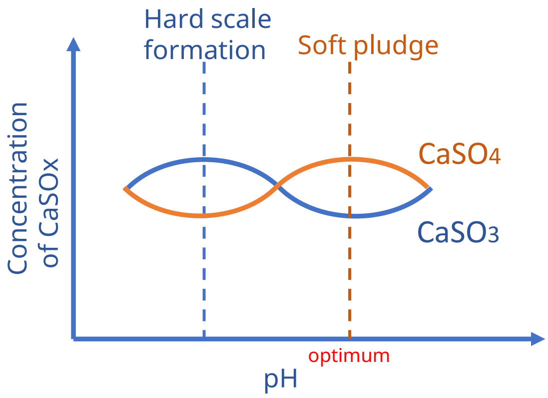
The scrubbing liquor can be bubbled through a slurry of either lime ($Ca(OH)_2$) or limestone ($CaCO_3$) and water. Either lime or limestone will combine with the sulfite ions from the flue gas to form gypsum, $CaSO_3$. The SO_2 captured in a scrubber combines with the lime or limestone to form several by-products. A primary by-product is calcium sulfate, commonly known as gypsum. Spent scrubbing liquids are sent to a clarifier, where the insoluble gypsum is removed, and the water is returned to the scrubber system.

The addition of lime or limestone to the scrubbing solution is controlled by monitoring the pH of the solution. Lime slurries are generally alkaline, with a control point near pH 12, while limestone slurries are more neutral.



pH Control

A pH measurement is one of the testing methods used to monitor the continuous blowdown and replenishment. The SO_2 within the scrubbing gases can be controlled by maintaining the level of caustic scrubbing chemicals that are commonly used. pH is a critical factor for the proper operation of a scrubber. It is also difficult to measure due to 2-15% solids and tendencies towards scaling, coating, and plugging.



The $CaSO_4$ concentration decreases slightly as pH decreases. Furthermore, because the dissolved oxygen concentration in the slurry is constant, sulfate formation depends only on the concentration of SO_3. The precipitation of $CaSO_4$ increases as pH decreases. Thus $CaSO_4$ is apt to form scale at a lower pH. Hard scale formation can be controlled by keeping the pH high.

The solubility of $CaSO_3$ increases significantly as pH decreases, or conversely, $CaSO_3$ forms a precipitate as pH increases. If the pH is too high, “soft pluggage” occurs. Soft pluggage is due to the formation of calcium sulfite precipitates, which appear as large leaf like masses. Maintenance of equipment that has a soft pluggage is more manageable than equipment that has a hard scale. In many cases where soft pluggage has occurred, it can be melted off simply by lowering the pH (increasing solubility).

It is obvious that a potential dilemma exists; operation at too low pH promotes the formation of hard scale, and operation at too high pH promotes the formation of soft pluggage. Only through experience can the proper pH range be determined. Typically, limestone is added to achieve the desired level of SO_2 removal based on the sulfur content of the coal, the boiler load, and the monitored SO_2 concentration of the flue gas while maintaining the pH in the reaction tank at 5.5 to 6.0 pH. The pH sensor can be located in the re-circulating tank or line.

Conductivity Control

Conductivity is one of the most common testing methods to monitor the concentration of scrubbing chemicals and by-products. As the concentration of the scrubbing chemical is depleted, its contribution to the total conductivity value will also decrease. However, simultaneously, the contribution to conductivity from the by-products is increasing. Therefore, a measurable decrease in conductivity is detected as the scrubbing solution is depleted.

However, difficulties can arise when more than one gas is scrubbed. Different by-products will be formed depending upon the relative proportions of the gases, leading to variations in the conductivity background. Although a conductivity measurement can be difficult or impossible, it may still provide a useful alarm point to alert the operator to check a grab sample. In scrubbers where the scrubbing chemical concentration is maintained by continual replenishment and blowdown, conductivity can initiate blowdown to prevent high dissolved solids buildup.

In continual replacement scrubbers, conductivity can initiate blowdown to prevent high dissolved solids buildup. Toroidal or Inductive conductivity is the best measurement form in this application, and the sensor should be located where it will be exposed to a representative sample.

Product Recommendations

pH Measurement System

Transmitter
FLXA202 /FLXA21 2-wire pH/ORP measurement system
FLXA402 4-wire pH/ORP measurement system

Sensor
Option 1: FU20/FU24 pH/ORP Combination electrode
Option 2: FF20 Flow-thru assembly with seperate measure, reference and temperature electrodes. i.e. SM21-AG4, SR20-AP24 and SM60-T1; SC21C- AGC55 and SM60-T1
Option 3: FU20-FTS pH/ORP Differential pH electrode

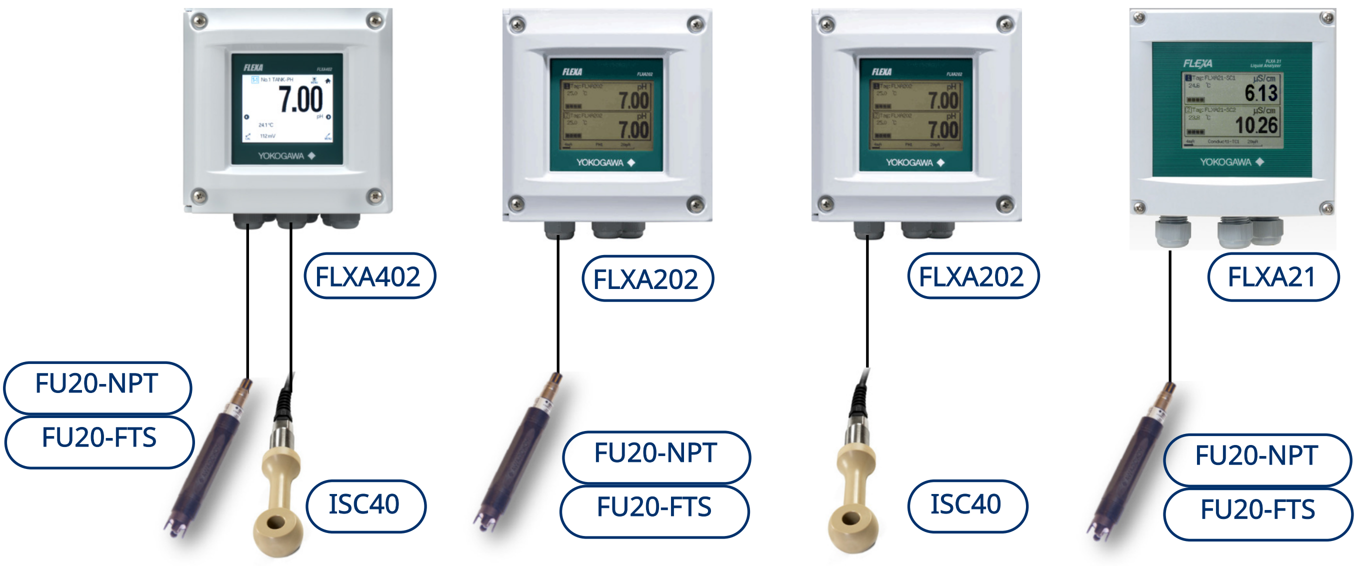
Conductivity Measurement System

Transmitter
FLXA202 /FLXA21 2-wire pH/ORP measurement system
FLXA402 4-wire pH/ORP measurement system

Sensor
ISC40 Inductivity Conductivity electrode with various installation options(insertion, flow through, retractable).

Configurations

2-wire/ 4-wire pH and Conductivity Measurement Systems		
Transmitters		
FLXA202/ FLXA21	2-wire Analyzer	General purpose, Intrinsic safety
FLXA402	4-wire Analyzer	General purpose
Sensors		
FU20-FTS	Differential pH/ORP sensor	with WU10-V-D
FU20-NPT	pH/ORP Combination sensor	fixed cable
SM21-AG4, SR20-AP24 and SM60-T1	Industrial Electrodes for pH/ORP	with WU20 cable and FF20 Flow-thru assembly
SC21C- AGC55 and SM60-T1	Industrial Electrodes for pH/ORP	with WU20 cable and FF20 Flow-thru assembly
ISC40	Inductive Conductivity electrode	fixed cable



FLXA402 4-wire transmitter with FU20 pH sensor + ISC40 inductive conductivity sensor

FLXA202 2-wire transmitter with FU20 pH sensor

FLXA202 2-wire transmitter with ISC40 inductive conductivity sensor

FLXA21 2-wire transmitter with FU20 pH sensor

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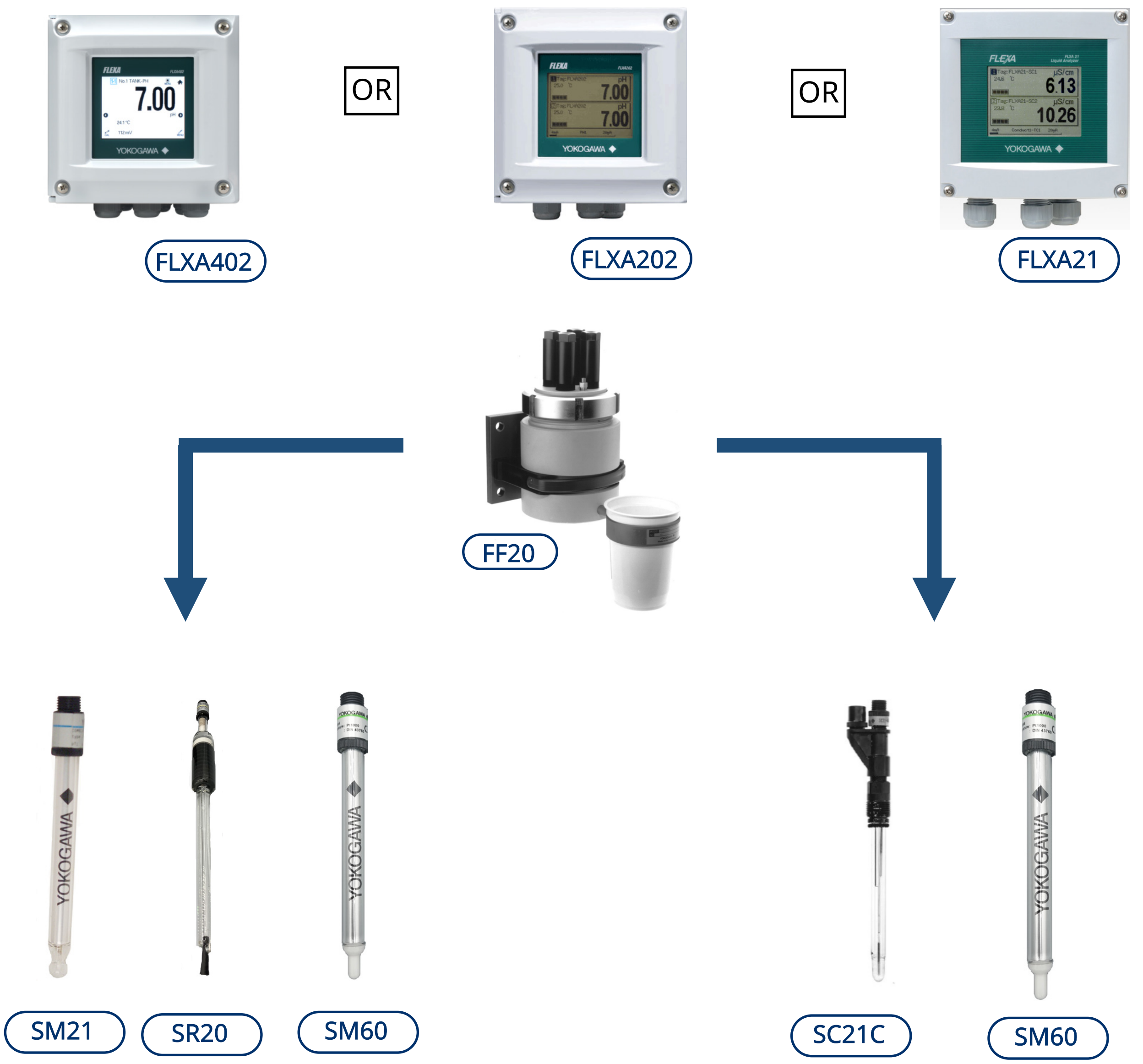

Combination of SM21 pH electrode + SR20 reference electrode + SM60 temperature sensor

Combination of SM21 combined pH electrode + SM60 temperature sensor

YOKOGAWA ELECTRIC CORPORATION
World Headquarters
9-32, Nakacho 2-chome, Musashino-shi
Tokyo 180-8750
Japan
www.yokogawa.com

YOKOGAWA CORPORATION OF AMERICA
2 Dart Road
Newnan GA 30265
USA
www.yokogawa.com/us

YOKOGAWA EUROPE BV
Euroweg 2
3825 HD AMERSFOORT
The Netherlands
www.yokogawa.com/eu

YOKOGAWA ELECTRIC ASIA Pte. LTD.
5 Bedok South Road
Singapore 469270
Singapore
www.yokogawa.com/sg

YOKOGAWA CHINA CO. LTD.
Room 1801, Tower B, THE PLACE
No.100 Zunyi Road
Changing District, Shanghai, China
www.yokogawa.com/cn

YOKOGAWA MIDDLE EAST B.S.C.(c)
P.O. Box 10070, Manama
Building 577, Road 2516, Busaiteen 225
Muharraq, Bahrain
www.yokogawa.com/bh

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